45TH TURBOMACHINERY & 32ND PUMP SYMPOSIA
HOUSTON, TEXAS | SEPTEMBER 12 – 15, 2016
GEORGE R. BROWN CONVENTION CENTER

MAINTENANCE PHILOSOPHY

JOHN P. JOSEPH II
ROTATING EQUIPMENT SYSTEMS TECHNICAL ASSOCIATES, LLC

TEXAS A&M UNIVERSITY
TEES TURBOMACHINERY LABORATORY
TEXAS A&M ENGINEERING EXPERIMENT STATION

Goal

- Develop a Maintenance Program that will Assure:
  - Safety of Personnel and Equipment
  - Environmental Compliance
  - Long Term Business Profit for Share Holders

Path

- Proper and Clear Operating Plans and Procedures
- A Supportive Maintenance Plan
- Thorough Risk Assessments and Safety Plan based on Risk Mitigation to an Acceptable Level
- Containment and Control to Meet Environmental Acceptance Levels
- Profit = Income (Revenue) – (Fixed Costs + Variable Costs + Annual Capital Expenditure)

Terms

- Income (Revenue) = Oil or Product Sales + Gas Sales
- Fixed Costs = People + Parts and Storage + Platform or Facility Support + Transportation + Project Support Overhead and Personnel
- Variable Costs = Maintenance Activities + Maintenance Parts + Chemicals + Contract Support + Vendor Support + Project Activities
- Annual Capital Costs = Yearly Capital Improvement or Expansion Program Costs

Incentives and Drivers for a Proper Maintenance Philosophy

- Every decision is an economic decision.
- What is the cost to mitigate risk versus paying for a safety or environmental event?
- What is the value of an incremental barrel per day of oil produced or product sold?
- What is the value of an incremental 1KSF per day of gas produced?
- What is the investment needed to achieve the incremental benefit?

Presentation Methodology

- Description of the types of maintenance
- Concerns, impact, and consequences of each type of maintenance related to the events
- Methods of tracking and analyzing events
- Modification of conditions, processes, or equipment to positively impact attainment and maximization of goals

Maintenance Philosophy

- There are four major classes of maintenance work activities.
  - Reactive or Breakdown Maintenance
  - Preventive Maintenance (PM)
  - Predictive Maintenance (PdM)
  - Pro-Active Maintenance (Pro-M)

Reactive or Breakdown Maintenance

- Reactive or Breakdown Maintenance is performed to reinstate equipment that had operated up to expectations until a point in time when the equipment quit functioning.
  - No monitoring system was available or used to indicate degradation or imminent failure.
  - No process data was available or used to indicate degradation or imminent failure.
  - The component just quit functioning properly.

Reactive or Breakdown Maintenance

- Reactive or Breakdown Maintenance Events
  - Concerns for this type of event are:
    - Unexpected loss of production and sales
    - Possible safety risks
    - Possible loss of containment

Preventive Maintenance (PM)

- Preventive Maintenance (PM) is performed on a scheduled basis to confirm equipment is suitable to continue service.
  - Schedules are derived from OEM input or historical data
  - Generally, readings or findings are pass fail criteria, or activity is replacement of components
  - Time based check or replacement of parts or fluids
  - Life limited parts are replaced based on time in service

Preventive Maintenance (PM)

- Concerns
  - Equipment may need to be taken offline.
  - Cost and schedule impact of PM can be substantial.
  - PM findings may require break down maintenance activity. (Inspection of coupling shim packs may reveal cracked or warped shims requiring shim pack replacement)

Predictive Maintenance (PdM)

- Predictive Maintenance (PdM) diagnostics are performed to measure and monitor the rate of degradation of equipment, parts, or systems.
  - Degradation is suspected or known to be a part of the equipment's use.
  - Measurable parameters exist to quantify the rate of degradation.
  - Rates of change can be linear or non-linear.

Predictive Maintenance (PdM)

- Concerns:
  - Diagnostic activities need to provide useable data.
  - PdM measurement data needs an economic cost component related to the loss of the performance due to degradation.
  - Cost and timing of overhauls need to coordinate with other unit equipment maintenance needs.
  - PdM scheduled maintenance activities need to be supported with parts and maintenance personnel at the scheduled time.

Predictive Maintenance (PdM)

- The choice to improve the equipment in a facility can be approached from different directions.
  - Component Reliability Improvements
  - Unit Availability Improvements
  - Plant Deliverability Improvements
- Each maintenance improvement approach has application in a complex plant with multiple process systems.

Tracking Maintenance Activities and Events

- Maintenance Management Systems – These systems are used to plan and schedule all types of maintenance activities, and to document the findings for future interrogation.
  - Computer Database Systems
    - Sophisticated software to plan, schedule, and document the activities.
    - Usually has “check the box” type data records keeping options. Needs ability to add text descriptions of findings.
  - Paper based systems
- Text based data needs to be added to either system to describe findings from each event.

Tracking Reactive or Breakdown Maintenance Events

- Review the data
- Analysis of data to develop information
- Analysis of information to develop knowledge
- Analysis and review of knowledge to make decisions for improvement

Tracking Preventive Maintenance Events

- Perform the scheduled event and log the activity and any findings.
- Analyze the condition found during the PM activity.
- Shorten the PM activity duration if conditions found are worse than expected.
- Lengthen the PM activity duration if conditions warrant to save costs.
- Replace PM activities with PdM diagnostics when degradation can be used to better schedule the maintenance activity. (oil condition monitoring rather than periodic oil changes)

Tracking Predictive Maintenance Events

- Maintenance activities are scheduled to correct the state of degradation at an economical time with consideration for production, TAR plans, and risk.
- Analyze the diagnostic data for trend information.
- Analyze the trend information in conjunction with production efficiency to determine economical time to overhaul the equipment back to peak performance.
- Analyze the economic knowledge derived to decide the timing for corrective intervention.
- Confirm the overhaul intervention achieved the peak performance expected. This analysis will provide the baseline for future PdM measurement activities to establish rate of degradation.

Improving Reactive or Breakdown Maintenance Impacts

- Improve process excursion limits and equipment component reliability improvements to reduce unexpected breakdowns.
- Evaluate component replacement costs to confirm component improvements are justified. (toaster)
- Consider system sparing philosophy when evaluating component improvement activities.
- If the Reactive Maintenance event repeats and costs are unacceptable, consider evaluating a PM or PdM method for intervention.

Improving Preventive Maintenance Impacts

- Conditions found during a PM activity should be analyzed to determine duration to next PM activity cycle.
- Extend or reduce PM intervals based on the condition assessment at previous PM activities.
- Establish teams that perform plant wide PM's for the efficiency and cost savings.
- Evaluate where PdM diagnostic activities and analysis to schedule needed maintenance can replace scheduled PM's.

Improving Predictive Maintenance Impacts

- Evaluate the PdM rates of change and intervention limits for suitability to the specific equipment. (ESMP's)
- Establish formal diagnostic procedures, protocols, and tools to achieve data accuracy.
- Establish calibration PM's for diagnostic tool data accuracy.
- Schedule the timing of the overhaul to get cost effective productivity from the equipment without risk of a catastrophic or costly failure.
- Establish procurement of replacement parts and scheduled service based on historical needs, and diagnostic data interrogation.
- Coordinate the scheduled overhauls with planned TAR's and when maintenance staffing is available.

Pro-Active Maintenance (Pro-M)

- Pro-Active Maintenance (Pro-M) is performed to change the equipment or conditions with the goal of interrupting the repeated failures of a component or system, or to change the rate of degradation. Pro-M is applied to:
  - Repeat failures that reduce or stop production
  - Repeat failures that expend significant funds for reinstatement
  - Repeat failures with unknown timing that can affect Safety and Environmental Compliance

Pro-Active Maintenance (Pro-M)

- Tools to use to rank Pro-M
  - Worst Actors List
  - Unspared Equipment Philosophy
  - Single Point of Failure Analysis
  - RCFA
  - Deliverability Models
  - Future Production Requirements
- Pro-M usually requires engineered changes to the design of components and systems.
- Pro-M also requires MOC review and risk mitigation.

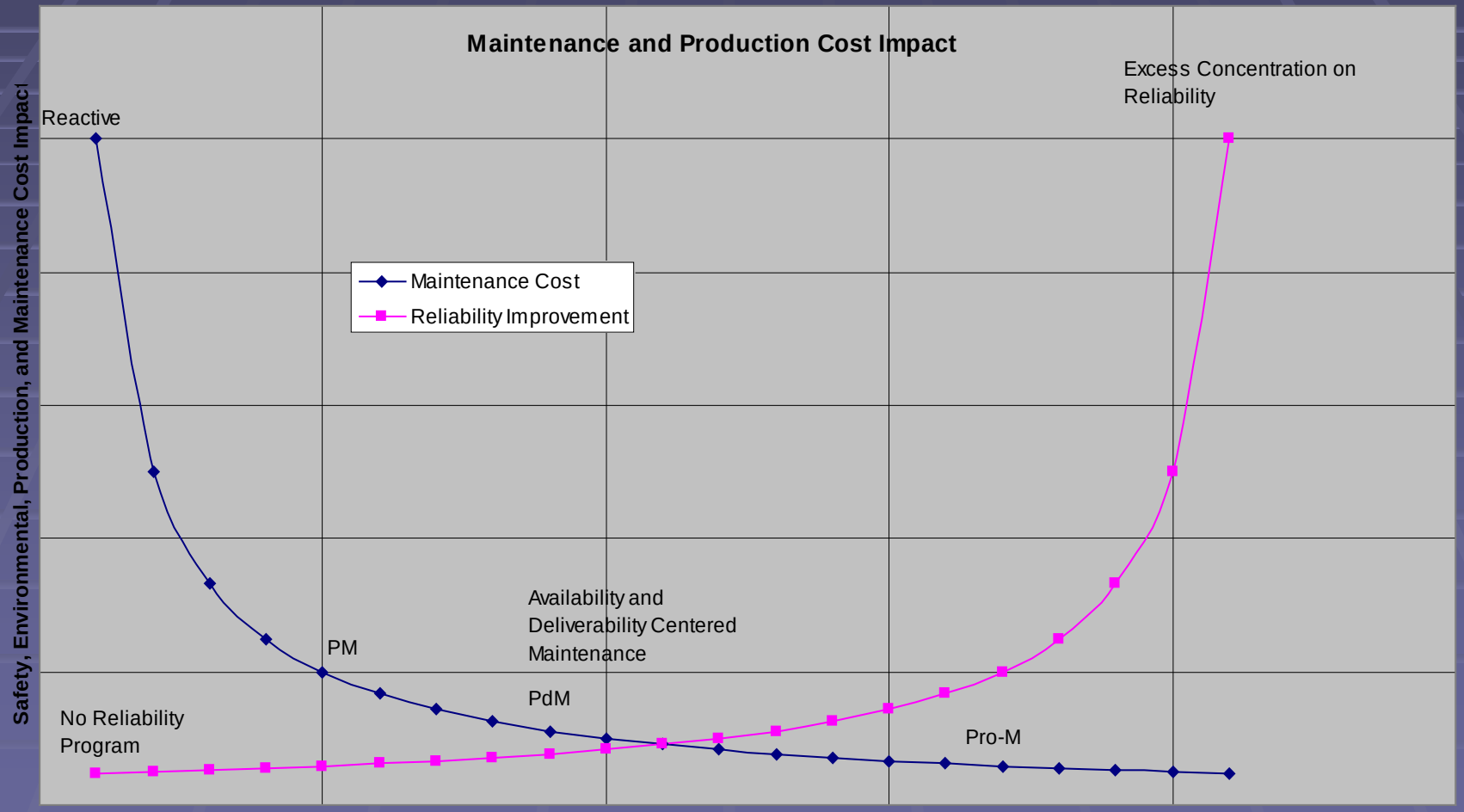
Tracking Pro-Active Maintenance Events

- Predict the safety and environmental improvements expected from Pro-M activities and the risk to success, along with cost to implement compared to expected cost savings.
- Predict the operational improvements expected from Pro-M activities and the risk to success, along with cost to implement compared to expected cost savings.
- Compare historical intervention intervals and maintenance costs with the duration and costs after the Pro-M is performed.
- Confirm the Pro-M applied to a worst actor eliminates the equipment from the list.
- Reorder the ranking of the worst actors list after Pro-M activities remove a piece of equipment.

Improving Pro-Active Maintenance Impacts

- Analyze the Pro-M effort on a plant wide and corporate wide basis to develop improvements to the methodology while publishing the successes.
  - Safety
  - Environmental
  - Profit

Maintenance Philosophy Cost Impact



Additional Areas of Savings

- Shared Equipment Philosophy
- Commonality of Design
- Spare Parts Philosophy
- Staffing Philosophy
- Procurement Programs with Preferred Vendors
- With all of these, the need exists to continually evaluate the cost benefit ratio with production losses included.

The Beginning

Questions and Comments